Navy Experimental Diving Unit
321 Bullfinch Rd.
Panama City, FL 32407-7015

TA03-05
NEDU TR 03-06
APR-2003

NAVSEA
NAVAL SEA SYSTEMS COMMAND
Navy Experimental Diving Unit

EVALUATION OF THE KMS 48 FULL FACE MASK WITH THE VIPER VERY SHALLOW WATER UNDERWATER BREATHING APPARATUS

20060213 034

S. J. STANEK
C. S. HEDRICKS

DISTRIBUTION STATEMENT A:
Approved for public release;
distribution is unlimited.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY
N/A

3. DISTRIBUTION/AVAILABILITY OF REPORT
DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited

2b. DECLASSIFICATION/DOWNGRADING AUTHORITY

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
NEDU Technical Report No. 03-06

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
Navy Experimental Diving Unit

6b. OFFICE SYMBOL (If Applicable)
033

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
321 Bullfinch Road, Panama City, FL 32407-7015

7b. ADDRESS (City, State, and Zip Code)

8a. NAME OF FUNDING SPONSORING ORGANIZATION
Naval Sea Systems Command

8b. OFFICE SYMBOL (If Applicable)
00C

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)
2531 Jefferson Davis Highway, Arlington, VA 22242-5160

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
		TA03-05	

11. TITLE (Include Security Classification)
EVALUATION OF THE KMS 48 FULL FACE MASK WITH THE VIPER VERY SHALLOW WATER UNDERWATER BREATHING APPARATUS

12. PERSONAL AUTHOR(S) **S. J. Stanek / C. S. Hedricks**

13a. TYPE OF REPORT
Technical Report

13b. TIME COVERED
FROM Jan 03 TO Mar 03

14. DATE OF REPORT (Year, Month, Day)
2003 Apr

15. PAGE COUNT
17

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Full Face Mask Testing,
VIPER Very Shallow Water Underwater Breathing Apparatus,
KMS 48 Full Face Mask

19. ABSTRACT: Testing assessed the abilities of the KMS 48 full face mask to operate properly with the VIPER very shallow water underwater breathing apparatus to its current maximum certification depth. The face mask functioned properly, and NEDU recommends adding the KMS 48 full face mask for use with the VIPER very shallow water underwater breathing apparatus to the Authorized for Navy Use list.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[ ] UNCLASSIFIED/UNLIMITED [X] SAME AS RPT. [ ] DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
NEDU Librarian

22b. TELEPHONE (Include Area Code)
850-230-3100

22c. OFFICE SYMBOL

DD Form 1473

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

CONTENTS

FIGURES

INTRODUCTION

Navy Experimental Diving Unit (NEDU) was tasked[1] to test and evaluate the KMS 48 full face mask (FFM) with the VIPER very shallow water (VSW) underwater breathing apparatus (UBA). Testing was designed to assess the abilities of the KMS 48 FFM to operate properly with the VIPER VSW UBA to the UBA's maximum certification depth, 50 feet of sea water (fsw).

Used by Naval Special Clearance Team One (NSCT 1) divers, the VIPER VSW UBA is a semiclosed-circuit, mixed gas (70% oxygen, 30% nitrogen), mechanically controlled partial pressure oxygen UBA. The UBA, with its constant mass flow rate of 4.5 liters per minute (L/min), is used primarily by divers performing low-visibility mine countermeasure (MCM) tasks against magnetic or acoustically sensitive ordnance. The KMS 48 (Figure 1) is a modular FFM specifically designed for semiclosed and closed-circuit diving operations. A seal exists between the nose and the mouth, and modular pods are used in the surface and dive positions. Two pods, both manufactured by Kirby Morgan, were tested by NEDU: the hard pod (Figure 2), which uses its own barrel valve, and the soft pod (Figure 3), which uses the VIPER's original barrel. These designs will improve diver safety by mitigating the effects of cold water during prolonged VSW MCM diving operations.

The purpose of the study was to assess the operational efficacy of the KMS 48 FFM with the VIPER VSW UBA. Tests were conducted to the UBA's maximum certification depth. No FFM is currently approved for the VIPER VSW UBA.

Figure 1. KMS 48 full face mask

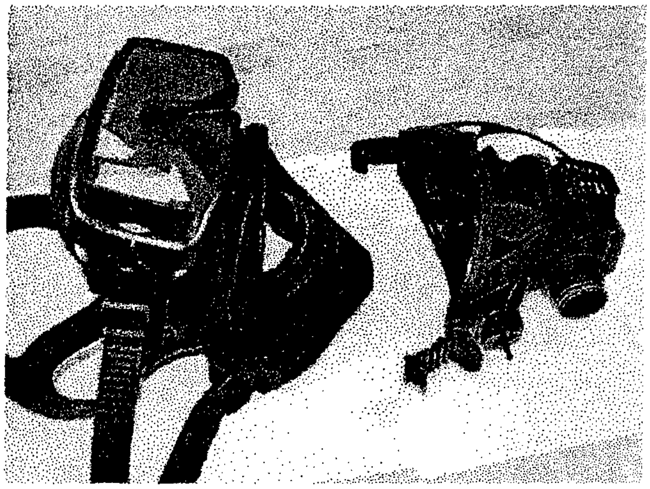

Figure 2. KMS 48 FFM hard pod

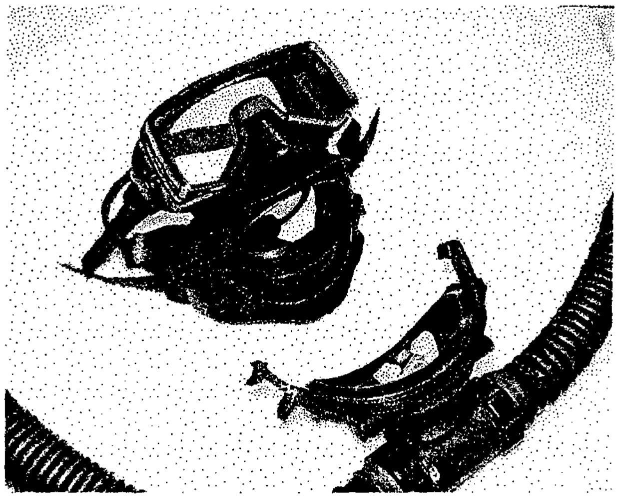

Figure 3. KMS 48 FFM soft pod

METHODS: UNMANNED EVALUATION

GENERAL

Unmanned testing of the KMS 48 was conducted in the Experimental Diving Facility (EDF) to ensure that breathing resistance was within acceptable limits. The following personnel and logistical support were required for testing: two KMS 48 FFMs (one with a hard pod, one with a soft pod), two VIPER VSW UBAs, and the EDF manned with a complete watch section.

Part of this evaluation included a comparison between the resistive effort of the KMS 48 with both hard and soft pods attached to a VIPER VSW UBA, and the historical EDF data on the resistive effort of the VIPER VSW UBA with a standard mouthpiece (barrel valve).

EXPERIMENTAL DESIGN AND ANALYSIS

The object of this test was to evaluate the KMS 48 FFM's influence on VIPER VSW breathing resistive effort at test depths of 0, 33, 66, and 99 fsw. All testing was conducted with the mouthpiece out of the mannequin's mouth.

The VIPER VSW UBA was evaluated under the following conditions:

1. Test depths: 0, 33, 66, and 99 fsw
2. Breathing medium: 70% oxygen, 30% nitrogen

3. Breathing rates: respiratory minute volumes (RMV) of 22.5, 40.0, 62.5, 75.0, and 90 L/min
4. Ark water temperature: Ambient (70 ± 5 °F)
5. Evaluation of two KMS 48 FFMs with both hard and soft pods was conducted at ambient temperature. In increments of 33 fsw, or one atmosphere absolute (ATA), the EDF was pressurized to the maximum depth of 99 fsw. At each ATA, breathing resistance data were collected (BPM = breaths per minute)

Breathing Rate	/	Tidal Volume	/	RMV
15 BPM	/	1.5 L	/	22.5 L/min
20 BPM	/	2.0 L	/	40.0 L/min
25 BPM	/	2.5 L	/	62.5 L/min
30 BPM	/	2.5 L	/	75.0 L/min
30 BPM	/	3.0 L	/	90.0 L/min

EQUIPMENT AND INSTRUMENTATION

a. EDF Bravo Chamber

b. Insulated rectangular water container (ark), 750-gallon capacity

c. Test stand with 90th percentile rubber head simulator (mannequin) mounted vertically

d. Mechanical breathing simulator with Reimers dual piston, variable volume 0–6 L and frequency to 40 cycles per minute; calibrated volume stops at 1.5, 2.0, 2.5, and 3.0 L; calibrated frequency stops at 15, 20, 25, and 30 BPM sinusoidal waveform

e. Pentium 200 megahertz (MHz) NT Workstation computer system with National Instruments LabVIEW data acquisition software and NEDU-developed software for processing resistive effort data

f. Oral/nasal differential pressure transducer [± 1 psid (6.9 kilopascals [kPa])] made by Keller, Inc., model number 289-545-0001

g. Two VIPER VSW UBAs

h. Two KMS 48 FFMs, one soft pod and one hard pod

PROCEDURES

Technicians conducted the initial setup/predive on the UBA per the operating manual[2]. They configured the UBA and FFM, connected the mannequin with the UBA to the chamber breathing machine, and conducted the dive profile. Gas supply was provided via the UBA's installed gas cylinders. Only NAVSEA authorized CO_2 absorbent Sofnolime, diving grade 8-12, mesh D, was used.

The resistive effort for the VIPER VSW UBA was measured with the UBA completely immersed in the upright position, mouthpiece out of the mouth. Tests were conducted at 22.5, 40, 62.5, 75, and 90 L/min at depths of 0, 33, 66, and 99 fsw.

The first dive to 33 fsw included breathing resistance tests with the adjustable exhaust valve (AEV) set fully closed, at midrange setting, and fully opened. For all subsequent tests, the AEV was at the approximate midrange setting.

RESULTS

Comparisons were made between the resistive breathing effort (work of breathing) for a VIPER VSW UBA with a KMS 48 mask and historical resistive breathing effort data for the VIPER VSW UBA with a standard mouthpiece (barrel valve). All VIPER VSW UBAs with the KMS 48 mask and pods were tested at ambient temperature, approximately 70 ± 5 °F.

<u>Temperature effects</u>
The KMS 48 mask was previously tested with the MK 16 MOD 1 UBA at 29 °F (-1.7 °C) and 104 °F (40 °C). The raw data from that report[3] was not published, but was reanalyzed for this report. That analysis showed a statistically significant reduction in resistive effort at 104 °F compared to 29 °F for RMVs ranging from 62.5 to 90 L/min with air at 190 fsw. When comparing results with heliox at 300 fsw there were no significant differences found across temperatures.

<u>Gas density corrections</u>
Based on the above results, for the current report we obtained data at 70 °F, and calculated the expected resistive effort at the temperature extremes of 29° F and 104 °F. We applied that temperature correction to only the worst case value, the resistive effort for the soft pod at 99 fsw and an RMV of 90 L/min. The average of two measured values at 70° F was 4.34 kPa. The resultant estimated resistive effort was 4.83 kPa at 29 °F and 4.13 kPa at 104 °F.

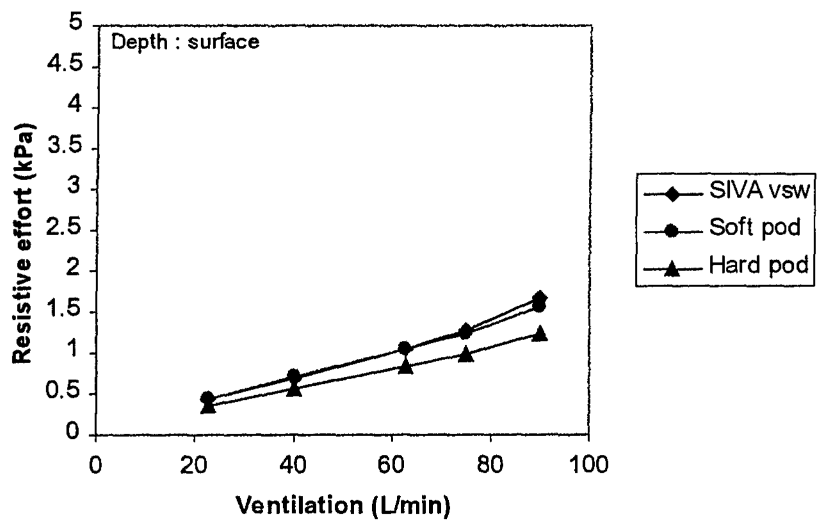

Figure 4. Resistive effort for the VIPER UBA at the surface, with the original mask and with the KMS 48 mask equipped with the soft and hard pods.

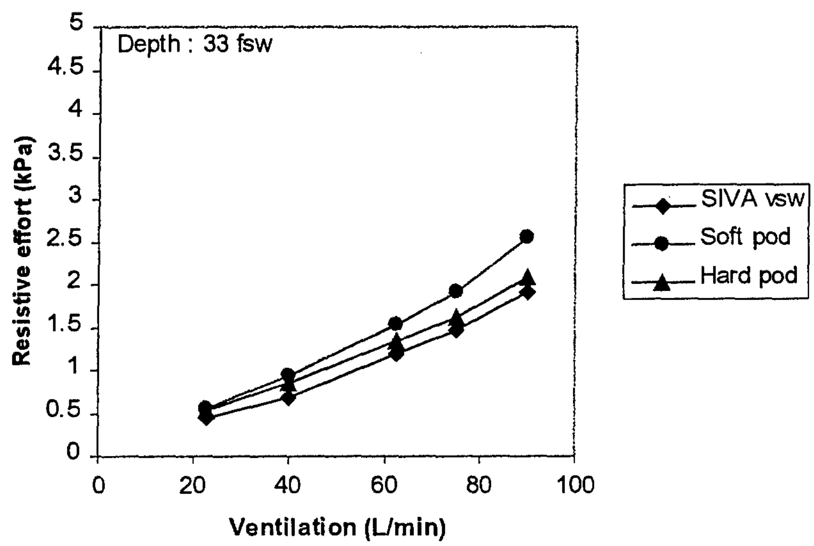

Figure 5. Resistive effort for the VIPER UBA at 33 fsw, with the original mask and with the KMS 48 mask equipped with the soft and hard pods.

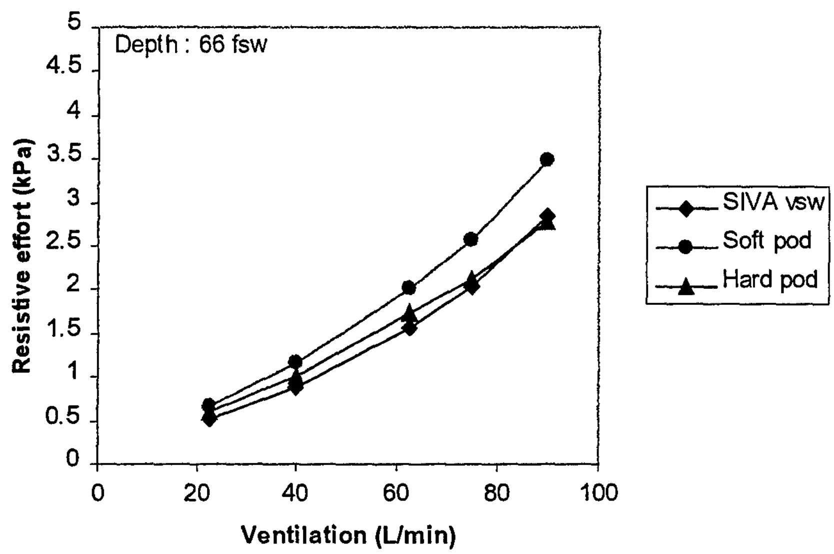

Figure 6. Resistive effort for the VIPER UBA at 66 fsw, with the original mask and with the KMS 48 mask equipped with the soft and hard pods.

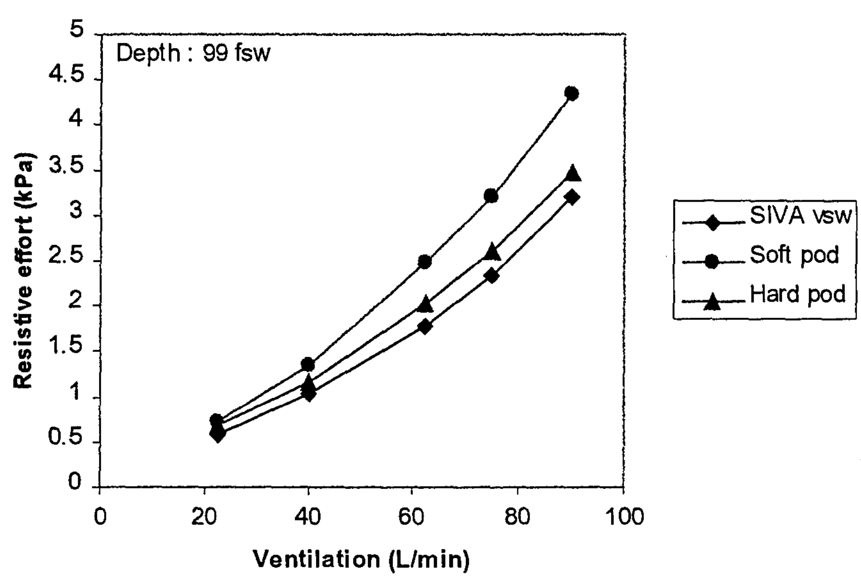

Figure 7. Resistive effort for the VIPER UBA at 99 fsw, with the original mask and with the KMS 48 mask equipped with the soft and hard pods.

CONCLUSIONS / RECOMMENDATIONS

On the average, the resistive effort for the soft pod was 29% higher to depths of 66 fsw, than that of the original VIPER specifications. The hard pod was not different from the VIPER with the standard mouthpiece to depths of 66 fsw. The higher resistive effort of the soft pod can be attributed to the smaller orifice of the mouthpiece used with this pod.

METHODS: MANNED EVALUATION

GENERAL

Manned testing of the KMS 48 with the VIPER UBA compared the Kirby Morgan hard pod to the Kirby Morgan soft pod. Phase I of the KMS 48 testing studied manned form, fit, and function (FFF) in the test pool. For Phase II, the UBA was dived to maximum operational depths in the 50-foot Buddy Breathing Ascent Tower (BBAT) at the Naval Diving and Salvage Training Center (NDSTC). Phase III involved manned open-water diving to depths of 30 fsw. All phases were conducted at ambient temperature which ranged from 55 ± 2 ° F in Phase III to 75 ± 2 ° F in Phase II. The same six divers were used throughout the manned evaluation.

EXPERIMENTAL DESIGN AND ANALYSIS

The objective of this test was to evaluate the form, fit, and function of the KMS 48 FFM when the VIPER VSW semi-closed UBA was dived to its maximum operational depths.

EQUIPMENT AND INSTRUMENTATION

The following personnel and logistical support were required:

Phase I: two KMS 48 FFMs, two VIPER UBAs (one hard pod and one soft pod), and a manned dive station with a minimum of three divers on the NEDU test pool.

Phase II: two KMS 48 FFMs, two VIPER UBAs (one hard pod and one soft pod), and a manned dive station with a minimum of three divers at the NDSTC BBAT.

Phase III: four KMS 48 FFMs, four VIPER UBAs (two hard pods and two soft pods), four Beuchat MCD 2 diver timer depth gauges and one dive boat outfitted with a complete dive station load-out for open ocean diving for a minimum of four divers. For all manned dives, a qualified VIPER diving supervisor was required.

PROCEDURES

Divers used safe diving practices, as set forth in the Viper VSW Operating Manual[2] and the U.S. Navy Diving Manual[4], to conduct all dives.

Phase I Testing — Form, fit, and function evaluation was conducted at a depth of 15 fsw in the NEDU test pool. These dives enabled the divers to familiarize themselves with the VIPER UBA and the KMS 48. Each diver conducted his dive with the KMS 48 with both the hard and soft pods.

Phase II Testing — Testing at NDSTC's BBAT repeated Phase I testing to a depth of 50 fsw.

Phase III Testing — Testing consisted of two days of open-water, open-ocean diving. This phase simulated a combat swim/dive for approximately two hours. Each diver performed one dive using the KMS 48 FFM with the soft pod and one dive using the hard pod.

RESULTS

The divers completed a series of dives consisting of pool and open-water dives to evaluate the KMS 48 FFM with both hard and soft pods. A total of 24 man dives were completed. Dives were conducted at depths ranging from 15 fsw (4.6 msw) to 50 fsw. Divers completed a human factors questionnaire containing 19 questions after the completion of Phases I & II, and again upon completion of Phase III. The KMS 48 FFM with hard pod and soft pod were scored on a scale of 1–6, with 4.0 or above being an acceptable score (1 = poor, 4 = adequate, 6 = excellent). The resulting averages of the human factors questionnaire (Annex A) are presented in Figures (8) and (9).

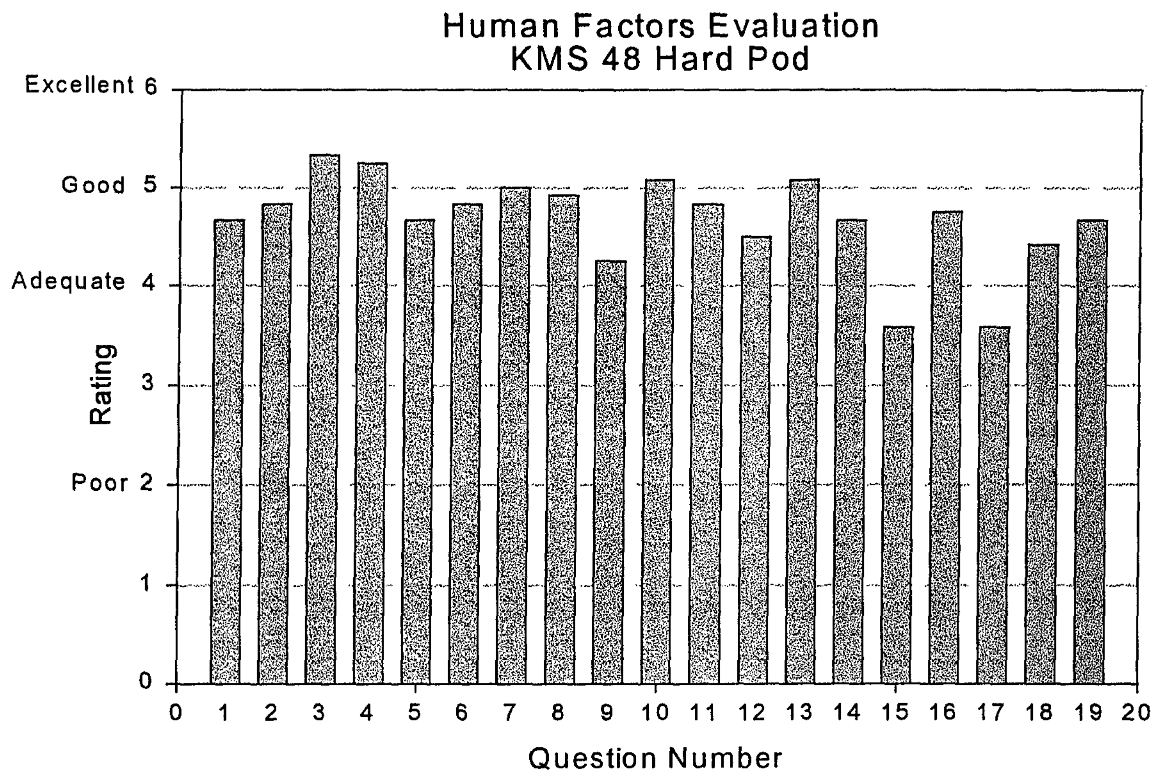

Figure 8. The averages for each question of the Human Factors Questionaire

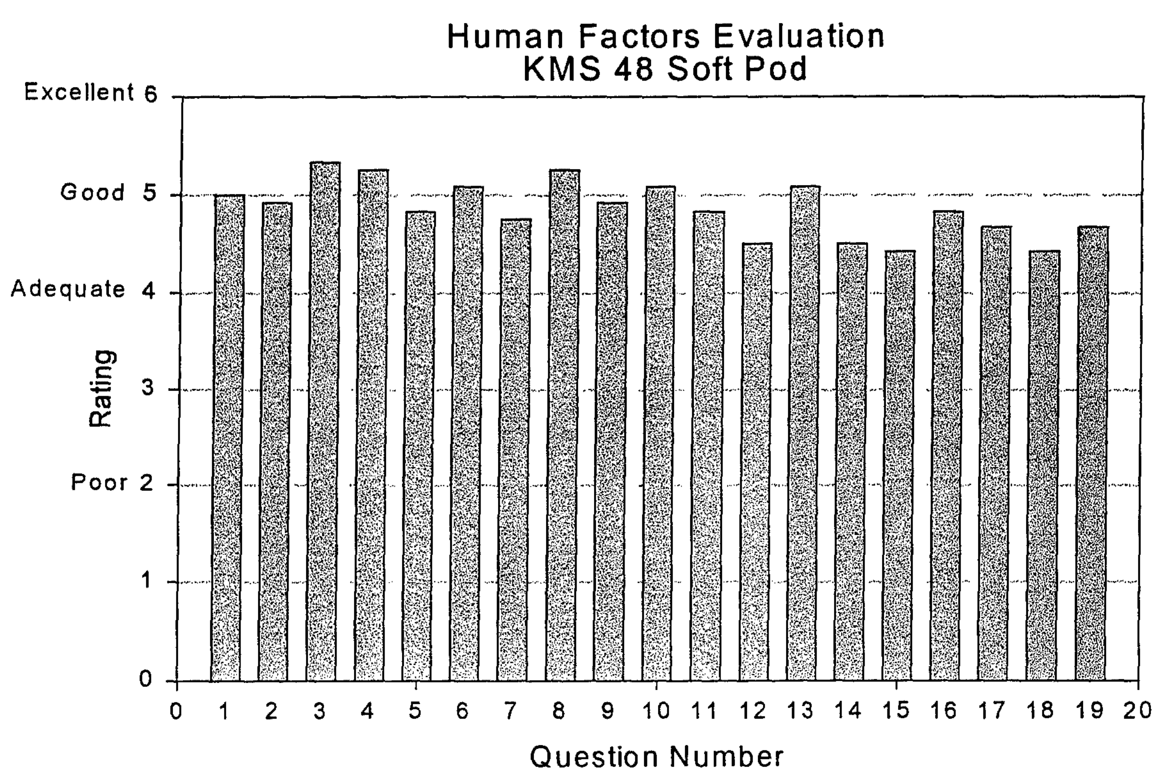

Figure 9. The averages for each question of the Human Factors Questionaire

CONCLUSIONS

The human factors evaluation and the performance of the KMS 48 FFM during the dives provided the quantitative and qualitative data necessary for recommending that this equipment be accepted for use with the VIPER VSW UBA. Averaged data from the human factors questionnaire determined both pods received satisfactory marks, 4.86 for the soft pod and 4.68 for the hard pod. In questions 15 and 17 the hard pod received unsatisfactory marks. These answers were comparisons to the soft pod, which had the higher approval rating. We feel that if compared to other UBA masks, such as the MK 24 FFM, these marks would have been much higher. Regardless, both masks received averaged marks above 4.0, the minimum level for recommending the ffm be considered mask for Navy use.

RECOMMENDATIONS

Manned testing, conducted in accordance with NEDU Protocol 03-05[5], revealed that the equipment performed adequately and we recommend adding the KMS 48 FFM to the Authorized for Navy Use (ANU) list for use with the VIPER VSW UBA. Our testing compared the Kirby Morgan hard pod with the Kirby Morgan soft pod. Overall, our testing showed that the divers preferred the soft pod, although both pods performed adequately.

REFERENCES

1. Commander, Naval Sea Systems Command, *Task Assignment 03-05: Test and Evaluate the KMS 48 Full Face Mask with the Viper Very Shallow Water (VSW) Underwater Breathing Apparatus (UBA)*, 30 Jan 2003.

2. Carleton Life Support Technologies Ltd, *Operating Manual: VIPER VSW Very Shallow Water Breathing Apparatus* (Mississauga, Ontario, Canada: Carleton Technologies, October 2002).

3. C. S. Hedricks and S. J. Stanek, *Evaluation of the KMS 48 Replacement Full Face Mask with the Emergency Breathing System for use with MK 16 MOD 1 Underwater Breathing Apparatus*, NEDU Technical Report 02-17, Navy Experimental Diving Unit, December 2002.

4. Commander, Naval Sea Systems Command, *U.S. Navy Diving Manual, Revision 4* (Arlington, VA: NAVSEA, 1999), Change A, 1 March 2001.

5. S. J. Stanek and C. S. Hedricks, *Manned Evaluation of the KMS 48 FFM for Use with the VIPER Semiclosed-Circuit Rebreather*, NEDU Protocol 03-05, Navy Experimental Diving Unit, February 2003.

ANNEX A

HUMAN FACTORS EVALUATION QUESTIONNAIRE
KMS 48 FULL FACE MASK

Name of Diver:______________________ Date of Dive:_____________

Actual Depth:_________ Actual Bottom Time:________

Brief description of dive: ____

____

Diver's dress:____

The following rating system is to be used for this questionnaire:

1 extremely poor	2 poor	3 not quite adequate
4 adequate	5 good	6 excellent

Overall comfort of the mask	SOFT / HARD POD / POD
1. How do you rate the ease of donning and doffing the mask?	____/____
2. How do you rate the ease of getting the harness over your head with the mask in place?	____/____
3. How do you rate the ease of tightening the straps?	____/____
4. How do you rate the ease of loosening the straps and doffing the mask?	____/____
5. How do you rate the visibility provided by the mask?	____/____
6. How do you rate the overall comfort of the mask, as it fit your face?	____/____
7. How do you rate the ease of preventing gas leaks around the face seal?	____/____
8. How do you rate the balance of the mask?	____/____
9. Rate the mask and pods for comfort.	____/____

Use and operation of the mask

10. While at rest, how do you rate the ease of breathing the mask?	____/____
11. How do you rate the ease of breathing the mask at a moderate work level?	____/____
12. How do you rate the ease of breathing the mask at heavy work levels?	____/____

13. How do you rate the ability of the mask to remain unfogged? ______/______
14. How do you rate the ease of clearing the mask after it has been flooded? ______/______
15. While wearing the mask, how do you rate the ease of speaking, mouthpiece bit out of the mouth? ______/______
16. How do you rate the ease of doffing the mouthpiece pod? ______/______
17. How do you rate the ease of donning the mouthpiece pod? ______/______
18. How do you rate the ease of clearing the mouthpiece and oral mask? ______/______
19. How do you rate the seal of the mask with the mouthpiece pod removed? ______/______

Please provide your personal preference between the two pods, and any additional information or comments about the mask.________________________________

____

____

____

____

____

____

____